NEARCTIC STONEFLY GENERA AS INDICATORS OF ECOLOGICAL PARAMETERS (PLECOPTERA: INSECTA)[1]

Richard W. Baumann[2]

Abstract.— Selected stonefly genera found in North America are classified as to their occurrence in: cold lotic, warm lotic, or lentic habitats. Most genera occur only in the cold lotic, but several occur both in cold and warm lotic systems. Few are found exclusively in warm lotic habitats and almost none in lentic. Lake or true lentic inhabits are found to usually be cold lotic species which have adapted to life in the wave-washed shores of cold mountain lakes.

Even though data at the specific level would be even more useful, especially where different faunal regions are involved, stoneflies are probably the best insect indicators of aquatic environmental quality at the generic level.

Illies (1970) presented the idea that the genus is the basic taxonomic unit of ecology and that systematists could gain valuable data for use in their classification of taxa by obtaining an understanding of the ecological requirements of the organism being studied. The converse should then also be true. If the phylogeny determined through the analysis of the systematics of a group is correct, then ecologists can predict the type of habitat present from a knowledge of the genera that live there.

Because environmental factors exert the selection pressure on populations that may cause some of them to evolve into new species, a level of habitat characterization must be reached that is narrow enough to be useful but broad enough to encompass large genera. Wiggins and Mackay (1978) classified the extant Nearctic Plecoptera, Ephemeroptera, and Trichoptera genera according to their occurrence in cold and warm lotic and/or lentic habitats. Their results for the Plecoptera showed that most genera occur in cold lotic waters, with decreasing numbers found in warm lotic and lentic habitats, respectively. However, they did not delineate those genera which occur in more than one habitat. Because such information is important, example genera were selected from each family and more complete data recorded.

Stoneflies were noted by Gaufin (1973) to be good indicators of water quality. However, their presence or absence alone is not enough on which to base any final conclusions. Some species are able to escape harsh conditions by emerging during the winter, when temperatures are low; others survive in microhabitats such as the rocky shores of lakes and small spring seeps. This makes it necessary to understand the biology of the species involved before conclusions can be drawn.

Materials and Methods

The nearctic stonefly fauna (Baumann 1976) was divided first into the groups Euholognatha and Systellognatha. These groups were then studied one family at a time, with an emphasis being placed on the common or most abundant genera.

Four ecological groupings were defined and characterized as shown in Figure 1. The two flowing water or lotic systems were divided according to mean temperature. No conclusive experimental data were available, so the 16 C isotherm is not final, but was chosen as a useful point of separation.

The lentic systems were likewise divided, but very little is known about the biology of stoneflies which occur in lentic habitats. The availability of proper substrate is, however, important.

[1]Presented at the workshop on indicator communities held at the North American Benthological Society meetings in Winnipeg, Manitoba, May 1978.

[2]Life Science Museum and Department of Zoology, Brigham Young University, Provo, Utah 84602.

Stream order classifications based on the Stream Continuum Theory of Cummins (1973) were included in an attempt to relate the functional ecology of the organisms occurring in lotic habitats.

Because published data about the occurrence of stoneflies is not available for many species, the field experience of the author in many parts of North America was relied upon heavily.

RESULTS

No stonefly genera occur in warm lentic habitats, probably because of the low oxygen level. Although most genera occur primarily in cold lotic habitats, there is a strong correlation even at the family level with adaption for existence in warm lotic or cold lentic habitats. For this reason, results are here presented according to systematic group and one family at a time.

The group Euholognatha consists of essentially herbivorous families which feed on detritus and plant material. The data (Fig. 2) show that most genera contain species which are found in cold lotic or cold lentic habitats. These habitats correspond ecologically to the functional classifications of Cummins from 1–6.

Cold lotic habitats are most often colonized by members of the family Nemouridae. These habitats occur at high altitudes or in spring-fed areas where temperatures remain cool throughout the year. Some species even survive in lakes, ponds, or swamplike areas with predominantly silt bottoms if some dead trees occur and provide a suitable substrate.

Genera in the Capniidae often have species which occur in warm lotic habitats. These species are only found in the nymph or adult stage during the cold winter months. They go into a diapause in the warm months, as noted by Khoo (1968). Several capniid species also occur in very northern arctic localities, where they emerge during late summer, when conditions are most favorable. Some species, including several members of the genus *Capnia*, are found in lakes at high altitudes and seem to emerge and complete their life cycle when the ice breaks. Only one species, *Capnia lacustra* Jewett (Nebeker and Gaufin), is strictly confined to a lotic habitat (Frantz and Cordone 1966).

Ecological Groupings	Habitat Characterization
Cold Lotic	Streams, creeks and rivers with mean temp. below 16 C; Includes orders 1-6.
Warm Lotic	Primarily rivers with mean temp. which often exceeds 16 C during warm months; Includes orders 7-12.
Cold Lentic	Ponds and lakes usually at high altitudes which never exceed 16 C in temp. Wave action and correct substrate also necessary.
Warm Lentic	Ponds and lakes which often exceed 16 C in temp. Bottom composed of sand, silt or other loose material.

Fig. 1. Ecological groupings and characterization of corresponding habitats based on stoneflies (Plecoptera: Insecta).

Many species in the family *Taeniopterygidae* occur in large rivers. The two most common North American genera, *Taeniopteryx* and *Taenionema*, contain several seemingly environmentally hardy species. Some occur in the large, silt-laden rivers of the West and others occur in the slow, sluggish bayous of the Southeast.

The Leuctridae are primarily found in clear, cold streams, but a few species do occur in large rivers.

The group Systellognatha (Fig. 3) contains two mainly herbivorous families, Peltoperlidae and Pteronarcyidae; two carnivorous families, Perlodidae and Perlidae; and the omniverous family, Chloroperlidae.

Members of the family Peltoperlidae are not well distributed in the nearctic region. They are found mostly in the Coast and Cascade mountains of the West and the Appalachian Mountains of the East, in small streams or creeks of good water quality.

The Pternoarcyidae are large in size and generally occur in large rivers. However, such species as *Pteronarcys princeps* (Banks) have adapted to life in the small streams of the Pacific Northwest, and the eastern genus *Allonarcys* is found commonly in small creeks.

The family Perlodidae contains many gen-

Family and Genus	Cold Lotic	Warm Lotic	Cold Lentic	Warm Lentic
Nemouridae				
Amphinemura	+	+	+	0
Malenka	+	0	+	0
Nemoura	+	0	+	0
Ostrocerca	+	0	0	0
Podmosta	+	0	+	0
Shipsa	+	0	0	0
Zapada	+	0	+	0
Capniidae				
Capnia	+	+	+	0
Isocapnia	+	0	0	0
Mesocapnia	+	+	0	0
Utacapnia	+	+	0	0
Taeniopterygidae				
Taenionema	+	+	0	0
Taeniopteryx	+	+	0	0
Leuctridae				
Leuctra	+	+	0	0
Megaleuctra	+	0	0	0
Paraleuctra	+	0	0	0

Fig. 2. Ecological groupings for the most common genera in the stonefly families of the Euholognatha. + = occurs, O = does not occur.

Family and Genus	Cold Lotic	Warm Lotic	Cold Lentic	Warm Lentic
Peltoperlidae				
Peltoperla	+	0	0	0
Yoraperla	+	0	0	0
Pteronarcyidae				
Allonarcys	+	+	0	0
Pteronarcys	+	+	0	0
Perlodidae				
Arcynopteryx	+	0	+	0
Cultus	+	+	0	0
Diura	+	0	+	0
Isogenoides	+	+	0	0
Isoperla	+	+	0	0
Hydroperla	+	+	0	0
Megarcys	+	0	0	0
Perlidae				
Acroneuria	+	+	0	0
Calineuria	+	+	0	0
Claassenia	+	+	0	0
Hesperoperla	+	+	+	0
Neoperla	+	+	0	0
Paragnetina	+	+	0	0
Perlesta	+	+	0	0
Chloroperlidae				
Alloperla	+	0	0	0
Paraperla	+	0	+	0
Swallia	+	0	0	0
Sweltsa	+	0	0	0

Fig. 3. Ecological groupings for the most common genera in the stonefly families of the Systellognatha. + = occurs, O = does not occur.

era which contain few species. They are carnivores and are generally not common in most systems. Several genera such as *Hydroperla* have, however, become very successful in areas where few stoneflies occur because they are able to take advantage of the food resources available but escape the harsh conditions by a diapause of some kind (Oberndorfer and Stewart 1977). Some genera such as *Arcynopteryx* and *Diura* are very successful in cold lakes at northern latitudes.

Most genera in the Perlidae have species that occur in large, warm rivers. Such genera as *Perlesta* and *Neoperla* occur in areas where no other stoneflies can exist and emerge and complete their life cycles during the hottest part of the year. Only the western genus *Hesperoperla* is known to have adapted to life in spring-fed ponds.

Chloroperlidae are generally very sensitive to environmental eutrophication and occur only under very favorable conditions. They are generally only found in cold lotic systems. *Paraperla frontalis* (Banks) has, however, been collected at or near the mouth of several lakes in Glacier National Park and also in the Canadian Rockies.

Discussion

Stoneflies are useful as indicators of environmental quality at the generic level. Such families as Leuctriidae and Chloroperlidae contain mostly genera which can survive only in cold lotic habitats. However, other families such as Perlodidae and Perlidae have many species that are well adapted to life in warm lentic environments.

Care must be taken to understand the environmental requirements of each species. Often *Neoperla* species occur in headwater streams as well as large rivers, and *Hesperoperla pacifica* (Banks) occurs in springfed streams, creeks, and large rivers. Such genera as *Capnia* and *Arcynoteryx* do not seem to support the idea that the genus is an ecological entity because they contain species that occur both in lotic and lentic habitats. However, when the requirements of the species that occur in the cold lotic systems are examined, they are found to be the same but are simply supplied by waves washing the shore instead of a flowing current.

At the present time, no stoneflies are known to occur in warm lotic habitats in North America.

Literature Cited

BAUMANN, R. W. 1976. An annotated review of the systematics of North American stoneflies. Perla 2:21–23.

CUMMINS, K. W. 1973. Trophic relations of aquatic insects. Ann. Rev. Ent. 18:183–206.

FRANTZ, T. C., AND A. J. CORDONE. 1966. A preliminary checklist of invertebrates collected from Lake Tahoe, 1961–1964. Occas. Papers Biol. Soc. Nevada, Reno 8:1–12.

GAUFIN, A. R. 1973. Use of aquatic invertebrates in the assessment of water quality. Special technical publication 528, American Society for Testing and Materials, Philadelphia, p. 96–116.

ILLIES, J. 1970. Die Gattung als ökologische Grundeinheit. Faunistisch-ökologische Mitteilungen, Kiel 3:369–372.

KHOO, S. G. 1968. Experimental studies on diapause in stoneflies. I. Nymphs on *Capnia bifrons* (Newman). Proc. R. ent. Soc., London 43:40–48.

OBERNDORFER, R. Y., AND K. W. STEWART. 1977. The life cycle of *Hydroperla crosbyi* (Plecoptera: Perlodidae). Great Basin Nat. 37:260–273.

WIGGINS, G. B., AND R. J. MACKAY. 1978. Some relationships between systematics and trophic ecology in nearctic aquatic insects, with special reference to Trichoptera. Ecology 59:1211–1220.